PROJECT DATA

Michigan Technological University - 02GO12062

Enabling Tool for Innovative Glass Applications

Recipient:	Michigan Technological University	Instrument Number:	DE-FG36-02GO12062
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Subcontractor(s):		B&R Number(s):	ED1906020, ED1805000
		PES Number(s):	02-2140, 02-2274
EERE Program:	Industrial Technologies	State Congressional District:	M I - 1

PROJECT SCOPE: The goal of the project is to develop an abrasive waterjet cutting system, using glass as the abrasive media, for new and existing glass production facilities. Objectives include the scaling up and refinement of a circuit used for the production of glass abrasives, the optimization of cutting methods, and utilization of the resulting glass waste stream as filler in various polymers. It is conceivable that a reduction of 10% to 15% in the size of feed stock will result.

FINANCIAL ASSISTANCE

Approved DOE Budget:	$200,000	Approved DOE Share:	$200,000
Obligated DOE Funds:	$200,000	Cost Share:	$0
Remaining Obligation:	$0		
Unpaid Balance:	$95,117	**TOTAL PROJECT:**	**$200,000**

Project Period: 10/01/02 to 09/30/04

TECHNICAL PERFORMANCE
DE-FG36-02GO12062
Michigan Technological University
Enabling Tool for Innovative Glass Applications

PROJECT SYNOPSIS

This project will develop an abrasive waterjet cutting (AWJ) system, using glass as the abrasive media, for new and existing glass production facilities. Specific objectives include the scaling up and refinement of a circuit used for the production of glass abrasives, which was developed in the conceptual phase of this study. Further efforts will include the optimization of cutting methods and the utilization of the resulting glass waste stream as filler in various polymers. A thorough assessment will also be made of two existing glass manufacturing facilities, offering baseline data for the engineering of a new process incorporating AWJ cutting systems. A feasibility study will establish that an AWJ cutting system would not only offer greater flexibility in the manufacturing of glass products, but would do so using a more energy efficient means, minimizing waste, and eliminating CO_2 emissions being generated by systems presently in use.

It is conceivable that a reduction of 10% to 15% in the size of feedstock will result. Production of automotive glass products typically results in the generation of a waste stream that ranges from 18% to 23% in a conventional production facility. The greatest percentage of the waste generated is a result of the wide border, required for the flame break-out process to function, which ultimately is landfilled. This border will not be required with an AWJ system.

SUMMARY OF TECHNICAL PROGRESS

Parameters have been established for the second stage of crushing, and the large-scale results agree well with the lab-scale results. This indicates that full-scale production equipment and processes are capable of producing the desired results. An anvil insert (versus roller insert) was tested, but this produced a larger range of particle sizes, undesirable in a waterjet application. The Kice multi-stage aspirator proved to be very efficient and more cost-effective than the mesh, so it will be used in the remainder of the tasks.

Coleraine Labs is using the Smart Screen System (S^3) for final sizing. As the S^3 has only been used for particles in a wet stream, tests were performed to prove its applicability for use on dry particles. The tests were successful and proved that the S^3 can be used with dry particles. Coleraine will make some engineering modifications to enhance the throughput before processing the remaining tons of glass.

Ongoing work is being performed on the equipment circuit used in glass abrasive production. The circuit will be refined and serve as a base on which the commercial system will be based.

SUMMARY OF PLANNED WORK

Planned work for the remainder of FY04 will focus on completing the Abrasive Production and the Abrasive Waterjet Testing Tasks. Material from these tasks will be used in the Waste Separation Task. Researchers at Michigan Technological University will investigate to see if they can temper the small particles they will use in the abrasive waterjet. They will also begin the Water Separation and Characterization Task.

PROJECT ANALYSIS

Michigan Technological University will be requesting a six month, no-cost time extension. This will bring the end date to March 30, 2005, due to longer than anticipated scheduling, shipping and handling of the large test runs. Some shifting of budget will be required, as Task 1 is over budget. However, Michigan Technological University believes that money can be shifted from Tasks 3 and 4 without loss of scope on the remaining tasks.

Michigan Technological University was selected to exhibit this technology at the World's Best Technologies 2004 in Arlington, Texas in March. Selections were made by investors and commercialization experts on the basis of potential high-growth commercialization. Based on the current results and investor interest, the potential for successful commercial application of the technology is high.

ACTION REQUIRED BY DOE HEADQUARTERS

No action is required from DOE Headquarters at this time.

STATEMENT OF WORK
DE-FG36-02GO12062
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PROJECT GOAL

This project will develop an abrasive waterjet cutting system, using glass as the abrasive media, for new and existing glass production facilities. Specific objectives include the scaling up and refinement of a circuit used for the production of glass abrasives, which was developed in the conceptual phase of this study. Further efforts will include the optimization of cutting methods, and the utilization of the resulting glass waste stream as a filler in various polymers. A thorough assessment will also be made of two existing glass manufacturing facilities, offering baseline data for the engineering of a new process incorporating AWJ cutting systems. A feasibility study will serve to establish that an AWJ cutting system would not only offer greater flexibility in the manufacturing of glass products, but would do so using a more energy efficient means, minimizing waste, and eliminating CO_2 emissions being generated by systems presently in use.

DETAILED TASK DESCRIPTION

Task 1. Media Production / Process Circuit Development

A considerable portion of the work plan effort will involve the scaling up of the process developed in the conceptual stage of this study. Having already shown that it is possible to produce abrasives suitable for use in an abrasive waterjet system from a variety of glass waste streams, using lab and pilot plant scale equipment, efforts will shift to the demonstration plant level. Though there will still be considerable activity at the pilot plant level, the greatest emphasis will be directed towards runs using commercial equipment. Processing of the glass will be carried out at a number of commercial equipment manufacturers test facilities (Metso Minerals, T.J. Gundlach, and others), allowing for the use of full-scale equipment that would typically be found in a commercial operation.

Although air classification, being much more efficient, is the primary means of separating the fine glass particles from the stream following each stage of reduction, conventional screening is still required for the final sizing of the abrasive product. With conventional screening being considered the bottleneck in this process, or serving as the greatest hindrance in the circuit, a great deal of study has been ongoing in an effort to resolve this issue. A revolutionary new screening system in which the flow of energy is controlled and confined to the screen panel itself, rather than shaking the entire mass of the machine, has become available. The resulting benefits include up to 96% reduction in energy requirements, decreased blinding, increased production and, as a result, a potential increase in effective surface area of up to 93%, given the same foot print. By incorporating this system into the circuit it is anticipated that any barrier previously imposed by the use of conventional screening will be alleviated. It is their intent, in this phase of the study, to utilize the Smart Screen System for the separation of the abrasive product from the liftings produced as a result of the air classification of the discharge resulting from the different stages of reduction. By incorporating both air classification and the S^3screening system into the media production circuit, not only will there be a considerable reduction in energy requirements, but the material handling requirements will be reduced as well.

Task 2. Abrasive Waterjet Testing

Though there was a considerable array of AWJ tests conducted to produce the results generated in the conceptual phase, given the limited amount of time and funding, there were a number of new theories that could not be addressed in that earlier phase of the study. There are a significant number of manufacturers that now serve the waterjet industry by offering components of their own design that have greatly improved the performance of the AWJ. One such design, from AccuStream, serves to minimize the energy loss by improving the blending or entrainment of the abrasive with the high pressure stream of water through the use of a newly designed mixing chamber. In this study it would be their intent to modify the existing system and incorporate a number of these recently developed components, which would greatly improve the performance of the abrasive waterjet system.

Further AWJ testing would then be conducted utilizing the glass abrasive that will be generated in Task 1 using commercial scale equipment. A matrix of tests will be established that will allow for the variation of the parameters associated with the operation of an AWJ cutting system. The primary parameters that will be taken into consideration will be jet pressure, orifice diameter, and nozzle diameter, while utilizing new components that have been manufactured by various firms. Nozzles will be provided by Boride Products or others if necessary.

Task 3. Waste Separation and Characterization

Following the AWJ cutting of plate glass, during their initial study, it was established that the material generated during the cutting of the plate glass as well as significant percentage of the “spent” abrasive had been reduced in size and angularity as a result of the impact and erosional forces encountered during the cut. A particle size analysis indicated that a significant portion of the post-AWJ stream could be recycled back to be used once again as the media in the AWJ cutting process. A review of literature, as well as discussions with various firms using AWJ cutting systems, resulted in contacts being made with a manufacturer of a new abrasive recycling system.

This new system, referred to as the WARD or Waterjet Abrasive Recycling Dispenser from WardJet, Inc., allows for the highly efficient means of removal of the reusable abrasive from the waste stream. It is then processed so that it may ultimately be returned to the AWJ system abrasive hopper for reuse. The removal of the coarse fraction would provide additional benefits because the remaining fraction would have a mean particle size that would be considerably smaller and as a result could serve as a filler for various polymers with a considerable market value.

Further processing of the fine particles resulting from the separation of the post-AWJ glass using the WARD abrasive recycling system will be considered, with the potential of producing a spectrum of glass fillers based on particle size. Although wet screening had been used in the initial phase of this project and proved to be very effective, alternatives such as using a hydrocyclone while the fine particle fraction is in the form of a slurry or air classification once in the dry state to classify the fines generated will be studied in the developmental phase. The resulting fractions will be characterized to determine particle size and morphology. Further efforts will also be made to establish additional uses for the resulting fractions.

Task 4. Plastic Fillers

With the plastic industry being directly dependent upon oil production and the cost of polymers being reflected in the availability of petroleum, there have been major efforts undertaken in recent years toward greater utilization of fillers in plastic products. The use of fillers serves to reduce the amount of polymer used in the production of plastic components and in many applications offering enhanced properties. This has resulted in an increase in the use of fillers in recent years. This increased interest has resulted not only in greater production of mineral fillers that have been widely used in the past, but also in an increase in the number of studies being undertaken to establish a variety of new fillers.

With the use of post-AWJ glass as a filler in polypropylene and high density polyethylene at levels of 10% and 20% in the initial phase of this study having exhibited good injection moldability, dimensional accuracy, surface quality, and mechanical properties, the intent would be to further expand these studies in the development phase. An additional investigation into the compounding of post-AWJ glass fines will be conducted by compounding three different polymers, polypropylene, high density polyethylene, and low density polyethylene with glass at concentrations of 0, 20, 30 and 40%. With this increase in the amount of filler being added to the base polymers, there is a greater concern for the integrity of the resulting compound. As a result, in this phase of the study the potential of surface treating the post-AWJ glass with various coupling agents will also be considered. Different fractions of the post-AWJ glass will be treated with various silane solutions, presently being used with other glass fillers, and in turn compounded with the three polymers being considered in this phase of the study. DOW Chemical will be providing the coupling agents as well as the polymers that are to be used in this phase of the project.

The resulting compounds will then be used in the injection molding of a number of tests specimens and some commercial parts that are being produced by commercial injection molding facilities presently serving the automotive industry at Baraga Plastics and Daimler Chrysler. The performance of the glass as a filler will be based on its performance in the injection molding process as well as the mechanical and physical properties of the resulting products.

Task 5. Technical Review / Economic Analysis of Glass Manufacturing Facilities

It is proposed that an initial plant assessment be conducted at two plate glass manufacturing facilities (Donnelly and PPG) to establish the baseline data for the energy requirements, efficiency, and environmental status of existing operations. With flame break-out and grinding being used extensively in most glass manufacturing plants, the conversion to an AWJ system would involve much more than the replacement of one machine with another. This study will involve a review of the systems presently in use, addressing the various parameters involved and collecting data to establish the requirements of these systems. This information will then be used to establish an energy balance for the existing systems and in establishing the feasibility of converting to an AWJ process.

Task 6. Engineering Design

To keep the transition from conception to commercialization free from obstacles, factors associated with the design and engineering of a commercial facility must be considered in the earliest stages. During the development of the circuit for the production of glass abrasives in the conceptual phase of this study, a considerable amount of thought went into the potential selection of manufacturers that produce equipment which would offer the best performance in the different stages in the reduction of glass plate to produce the glass media. In the same light, brief visits to the production facilities of two of their industrial partners' production facilities has provided an overview of the undertaking that would be involved in the conversion of such a facility from its present design to one that utilizes an AWJ cutting system. A major portion of this study would be directed toward the design and selection of equipment that would be suitable for use in the conversion of an existing glass manufacturing facility to one that incorporates the more efficient AWJ process in the cutting of plate glass, while eliminating the glass waste stream and greatly reducing CO_2 emissions.

Task 7. Feasibility Study

The feasibility study would address the variations in energy requirements and operating costs of the different systems, as well as the capital costs that would be involved in the conversion of the existing facilities to one which incorporates an AWJ system. As a result, the study would also provide a very good indication of the return on investment that could be expected.

Task 8. Project Management and Reporting

Michigan Technological University is responsible for submitting both Semi-Annual Progress Reports and a Final Report to DOE. The Semi-Annual Reports are due every April 30 and October 31. The Final Report is due 90 days after the project completion date as specified in the agreement. This task also includes other DOE requirements for market assessments, fact sheets, benefits analyses, workshops, etc.

Project Cost Performance in DOE Dollars for Fiscal Year 2003

DE-FG36-02GO12062 Michigan Technological University

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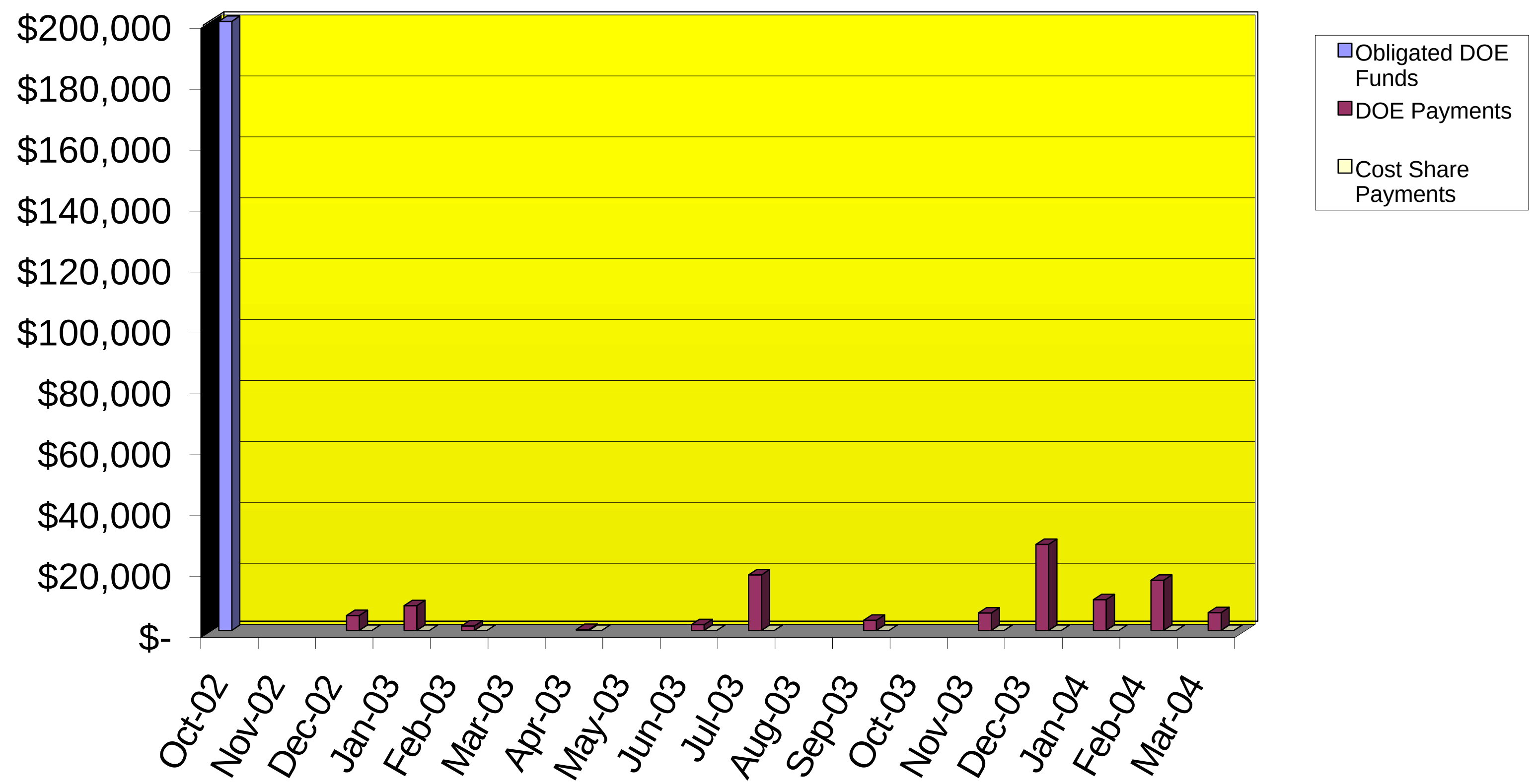

	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03
Obligated DOE Funds	$200,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
DOE Payment	$0	$0	$4,965	$8,158	$1,515	$0	$361	$0	$1,883	$18,224	$0	$3,344
Cost Share Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04	PFY*	Cumulative
Obligated DOE Funds	$0	$0	$0	$0	$0	$0	$0	$200,000
DOE Payment	$0	$5,778	$28,221	$10,099	$16,504	$5,831	$0	$104,883
Cost Share Payment	$0	$0	$0	$0	$0	$0	$0	$0

Approved DOE Budget:	$200,000
Approved Cost Share Budget:	$0
Total Project Budget:	$200,000

* Prior Fiscal Years

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